ECOSYSTEM SCIENCE AND TECHNOLOGY BRANCH

Automated Processing of Terrestrial Satellite Imagery Using Bayesian Methods

Chris Hlavka, Peter Cheeseman, John Stutz, Robert Slye

The typical approach to developing land cover/land use maps with satellite imagery involves defining spectral classes by clustering the image data and making assignment of classes to pixels. AutoClass, a general-purpose Bayesian classifier, was tested in terms of integration into the land cover map-making procedure and improved information content compared to products using other classifiers. Landsat Thematic Mapper (TM) images, ancillary data for interpreting and evaluating AutoClass results, were provided by the United States Geological Survey (USGS) offices in Menlo Park, California and the USGS in Reston, Virginia.

The current version of AutoClass is the product of years of development and refinement. It has been successfully used in several application areas from astronomy to biology. The LISP version of AutoClass was tested with Landsat data (a 1000 x 1000 pixel image). The results were promising in that tightly-defined classes were defined that were related to identifiable features of the scene, but not rigorously evaluated with "ground truth." Also, because the program was computationally intensive, the analysis took many hours on a massively parallel computer, a Thinking Machines Corporation Connection Machine (Model 2).

A newer, faster version of AutoClass written in C was tested on a moderate speed platform, a Sun Ultra 30. Software was written to convert imagery in a standard format used in remote sensing into the binary format used for AutoClass input. AutoClass-C was modified to classify image output in standard formats, enabling map product development and assessment with commercial remote sensing image analysis software. It was further modified to write class parameters in an ASCII file to enable maximum likelihood (ML) classification of a full image with classes defined by AutoClass on a pixel subset. The clustering/ML combination was implemented to allow AutoClass to be applied to mapping larger data sets.

Land cover products were developed for three sites—two small (~500 x 500 pixel, ~15 x 15 kilometers (km)) sites in Western Texas, and Nicholas County, West Virginia (2.2 million pixels, about 1,700 km^2). The small site maps were developed by clustering and classifying all pixels with AutoClass. The Nicholas County map (Fig. 1) was developed by clustering a sub-sample (every third row in every third column, or 1/9th of the pixels) with AutoClass to define spectral classes, followed by maximum likelihood classification of the full image. Aerial photography was used to relate spectral classes to cover types (road, developed areas, agricultural areas or crop types, types of natural vegetation, water) and assess map product quality. In addition, Centers for Disease Control ground observations in forested areas were used to assess the Nicholas County product, and to compare the AutoClass product to a USGS map product.

The AutoClass map products showed good definition of land–cover types associated with human activity. Discrimination among forest types was complicated by their occurrence in areas of topographic relief. The USGS map products were produced using a combination of Landsat TM and geographic information layers (maps of roads and slope/aspect), whereas the AutoClass maps were produced from Landsat TM alone, therefore a definitive comparison

between the performance of AutoClass (clustering based on probabilistic considerations) relative to a more traditional classifier (clustering based on distance) cannot be made yet. However, the AutoClass map products appear to provide more accurate maps in areas of low relief, and definition of subtle distinctions in vegetation types. Susan Benjamin, U.S. Geological Survey, Menlo Park, California, and Jim Falcone, U.S. Geological Survey, Reston, Virginia, collaborated in this research.

Point of Contact: Chris Hlavka
(650) 604-3328
chlavka@mail.arc.nasa.gov

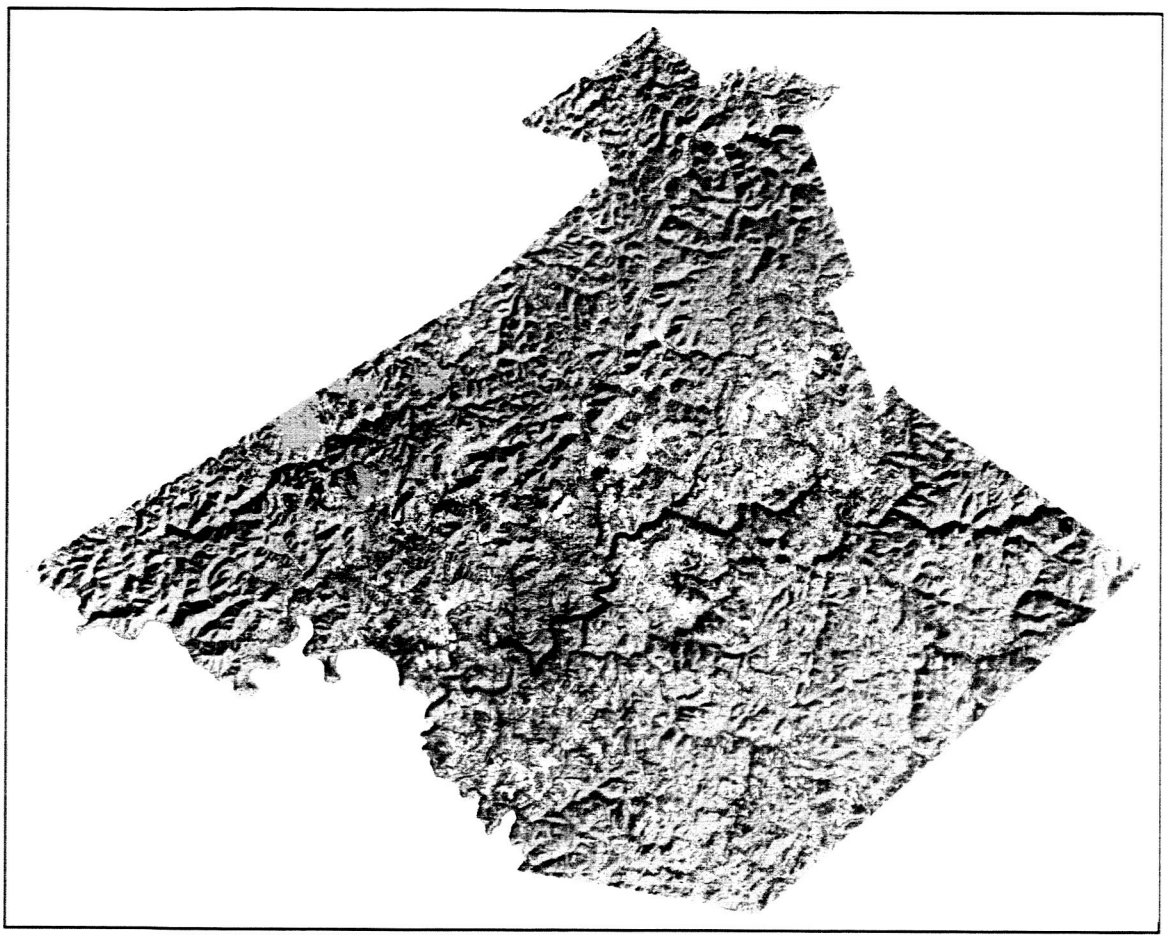

Fig. 1. Map of Nicholas County, West Virginia, produced by using AutoClass-C to process Landsat-7 Thematic Mapper imagery. [Color Code: hemlock forest - dark green; pine forest - purple; mixed forest - medium green; deciduous forest - light green; crops/pasture - yellow; towns/mines - gray; road/pavement - red; water - blue]